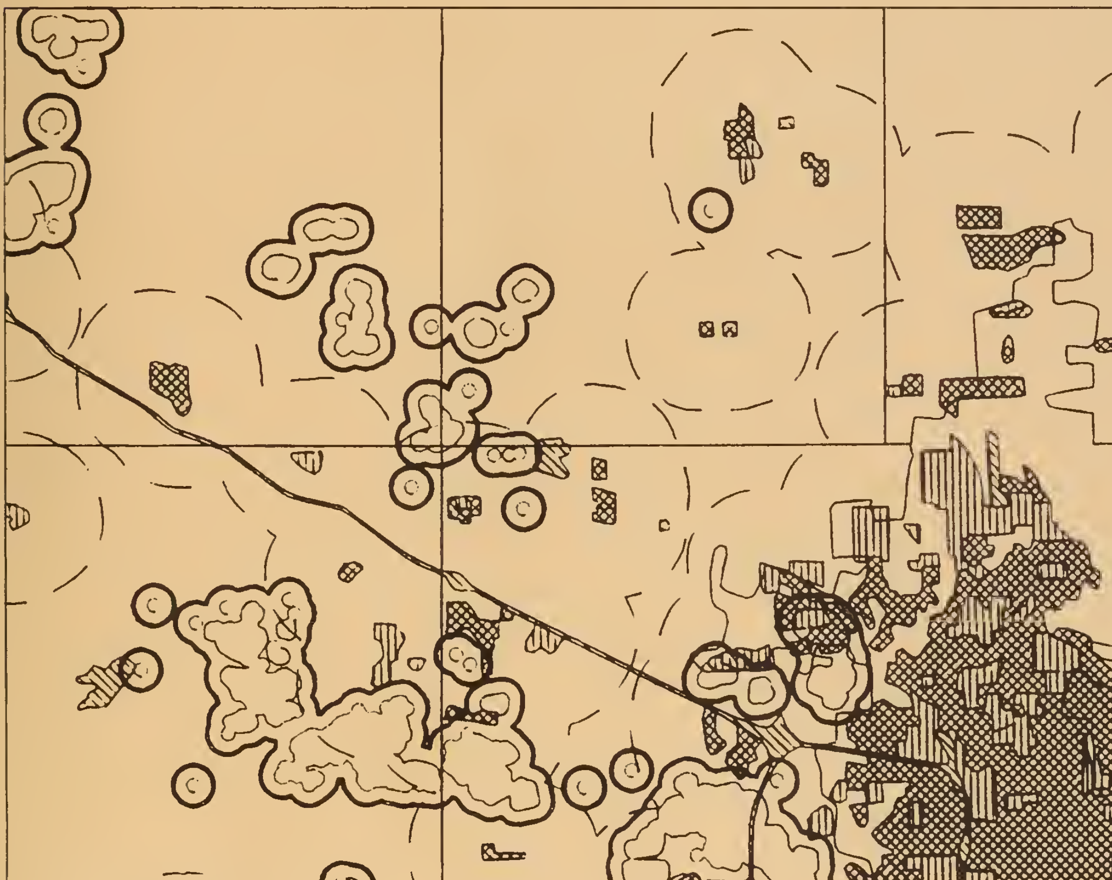
The Proximity of Underground Mines to Residential and Other Built-up Areas in Illinois



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ENVIRONMENTAL GEOLOGY 138

Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

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ABSTRACT
Ground movement resulting from mine subsidence—the sinking of ground surface after failure of pillars, floor, or roof strata in an underground mine—can cause damage to overlying structures and reduce property values. The greatest potential for mine subsidence damage to structures occurs where active or abandoned mines lie under or adjacent to cities, towns, and rural subdivisions.

In this study we calculated the acreage of four categories of undermined land in Illinois: (1) *residential*; (2) *other urban* (commercial, industrial, mixed residential and commercial); (3) *urban buffer* (a 1-mile area surrounding *residential* or *other urban* land); and (4) *nonurban.* We also estimated the number of housing units close to underground mines. Because the oldest mining operations in the state were generally located in and around populated areas, urban areas often have disproportionably higher percentages of undermined land than do adjacent rural areas.

Approximately 178,000 acres of residential and other built-up areas in Illinois are in close proximity to underground mines and may be exposed to subsidence. Although less than 4 percent of the land in the 77 counties studied is undermined, more than 21 percent of the *residential* land (109,000 acres) and more than 16 percent of the *other urban* land (69,000 acres) overlie or are adjacent to underground mines. An additional 878,000 acres of undermined land are within 1 mile of built-up areas. In Saline County alone, 87 percent of the residential land is in close proximity to underground mines. An estimated 320,000 housing units in the state are over or adjacent to underground mines.

This report is intended to alert planners, developers, local governments, and landowners to the presence of active or abandoned underground mines under or near urban and other built-up areas.

INTRODUCTION
Mine subsidence—sinking of the ground surface due to the failure of pillars, floor, or roof strata in an underground mine—can take place gradually or suddenly; it may develop as a sag over a large area or open up as a pit at the surface (DuMontelle et al. 1981). The ground movement may result in damage to overlying structures and reduction in property values.

More than 2,660 underground coal mines have been operated in Illinois since 1810; all but 30 have been abandoned. An additional 356 underground mines have been operated to extract industrial minerals and metals, including clay, fluorspar, lead, zinc, dolomite, limestone, ganister, and tripoli; all but 10 of these mines have been abandoned. Although subsidence has occurred over all types of mines in Illinois, most subsidence in the state is related to coal mines because of the extensive areas underlain by these mines. However, one of the state's largest subsidence events occurred near Galena over a lead-zinc mine (Touseull and Rich 1980).

Damage caused by ground movement is not insured under conventional property insurance. In 1979 Illinois became the second state in the nation to pass legislation (the Mine Subsidence Insurance Act) assuring the availability of insurance against mine subsidence damage to structures. The Illinois Mine Subsidence Insurance Fund (IMSIF) monitors subsidence claims and reimburses private insurance companies for claims paid for mine subsidence damage.

Prior to this study, the only quantitative information available on the distribution of mines in Illinois was the percentage of each county undermined by coal mines. This information was of limited value for assessing potential damage to structures: in some regions mines are directly under urban areas, whereas in others they underlie rural land having few significant structures. Furthermore, no statewide map database of the location and extent of mines that produced

industrial minerals and metals had ever been compiled. (The ISGS has maintained a map database of coal mines since 1950.)

The aim of the study was to provide more complete data on the proximity of built-up or urban areas to underground mines. We constructed a database on underground mines that produced industrial minerals and metals, and compiled statistics on the proximity of all known underground mines (coal and industrial minerals and metals) to built-up areas. A summary of the data and study methods used and an overview of our findings are included in the following sections of this report. Detailed documentation of the study, including information on the development of the database on underground industrial mineral and metal mines are found in Treworgy et al. (1989).

Although the presence of underground mines in an area does not mean that subsidence will or could take place, owners of property in the vicinity of mines should review their insurance coverage or consult with experts who can assess the potential for subsidence at that specific location. DuMontelle et al. (1981) provide additional information on subsidence for homeowners.

ASSESSMENT OF PROXIMITY OF MINES TO RESIDENTIAL AND BUILT-UP AREAS

To determine the proximity of underground mines to urban areas, we merged digital maps (maps converted into a computer-readable format) of the mined areas with digital maps and data on land use and housing. Geographic information system (GIS) software was used to process the data (Morehouse 1985). Six map data sets and two tabular data sets were merged to identify the type of land use and number of housing units in areas above or adjacent to underground mines. The GIS provided a mechanism to (1) manage the large volume of data, (2) define zones of risk around mines, (3) adjust and register spatial features between small-scale maps and large-scale maps, (4) merge spatial features and link them to the tabular data, and (5) summarize the results in both tabular and map form. Technical details of the GIS procedures used are described in Hindman and Treworgy (1989).

Source and Characteristics of Data

Data used for this study were collected over the past 20 years by government agencies and private companies (table 1). The scale of the spatial data sets makes them ideal for regional applications but too generalized for site-specific studies. Two important characteristics of the map data sets are the minimum size and the positional accuracy of geographical features. The minimum size of features depicted in the land use and coal mine map data sets is about 10 acres. Features smaller than 10 acres were omitted from the land use data set and are represented as a single point in the coal mine data set. Minimum size of features was not a factor for the other data sets.

Table 1 Original scale, date, and source of digital data used to evaluate the proximity of built-up areas to underground mines.

Data set	Scale of source of maps	Date of data	Source of data
Coal mines	1:1,200–1:62,500	1987	ISGS
Noncoal mines	1:120–1:63,360	1988	ISGS
Land use	1:250,000	1969-81	U.S. Geological Survey
Census tracts	1:62,500	1980	Geographic Data Technology (1982)
Block groups	1:62,500	1988	IL Dept. of Energy and Natural Resources
Political townships	1:24,000–1:500,000	1984	IL Dept. of Energy and Natural Resources
Census statistics	tabular data	1980	U.S. Dept. of Commerce (1980) and Donnelley Marketing (1986)

The accuracy with which features are located on a map depends on the scale of the source map and the standards, equipment, and procedures used to compile the map. Generally, the larger the scale of the source map the more accurate the positions of features on the final map product. However, wide variations in accuracy can occur between maps of the same scale. Old maps of underground mines can be particularly inaccurate because the surveyors had few control points and worked under difficult conditions. Once a mine is abandoned, there is no easy, inexpensive method of verifying its boundaries.

The process of digitizing maps can also introduce locational errors of about a line width; this means that on maps at a 1:24,000 scale, a map feature could be offset 25 feet from its true position, and on maps at a 1:250,000 scale, features could be offset by as much as 250 to 300 feet.

Coal mine data The Illinois State Geological Survey (ISGS) maintains a digital database on the location and extent of underground coal mines (Treworgy et al. 1988). These data were compiled in the early 1950s for use in estimating the coal resources remaining in the state. Updated periodically to include new mined-out areas, the maps were converted to a digital format in the late 1970s. The original data, compiled on base maps at a scale of 1:62,500, consisted of a point at the location of the mine entrance and a polygon outlining the extent of the mined-out area, if this area was known. Since 1984, the largest scale source map available (generally 1:4800 to 1:24,000) for each mine has been used for making additions and corrections to the database. Unmined blocks of coal within the mine perimeter are delineated if they cover an area of at least 400 x 400 feet (16,000 square ft). The mine boundaries used in this project reflect all known mining as of January 1987. In Fulton, Jackson, Knox, Peoria, and Stark Counties, some shallow underground mines have been mined through by subsequent surface mining and no longer exist. Because of the difficulty of identifying which mines are gone, all mines were included in this study. In all cases, these re-mined areas involve small mines in rural areas and have no significant effect on the results of the study.

Data on mines that produce industrial minerals and metals Using Cook's 1979 inventory of industrial mineral and metal mines as a guide, we collected information on 356 mines in the state (table 2) and compiled a database on these mines from maps and other sources of information available to the Survey. Mine maps were obtained from ISGS files, the U.S. Bureau of Mines, mining companies, and other sources. Because state and federal laws did not require companies to file mine maps with government agencies, maps showing the extent of mine workings were available for only about 20 percent of the mines, and the entire extent of the mine was not shown on some of these maps. When maps of known industrial mineral and metal mines were not available, the locations of the mines were obtained from reports, field notes, and topographic maps.

Land-use data The land-use data for this study were derived from digital data distributed by the U.S. Geological Survey (USGS) (Loelkes et al. 1983, Fegeas et al. 1983). The data were compiled from aerial photos, digitized at a scale of 1:250,000, and categorized, using the USGS Level I and Level II land-classification system. Land-use data for Illinois were collected from 1969 to 1981 and released in digital form in the early 1980s (table 3).

Census data The census data were obtained from the Office of Research and Planning, Illinois Department of Energy and Natural Resources. The tracts, block groups, and political townships are map data sets depicting some of the basic geographic subdivisions used in the 1980 census. The census statistics are the actual counts or projections produced by the 1980 census. The block groups and political townships were digitized by the Office of Research and Planning. The tracts and some of the tabular data are proprietary data sets purchased from commercial vendors. Other census statistics were from the U.S. Bureau of the Census.

Table 2 Underground mines producing industrial minerals and metals, compiled by county and commodity (1989).

County	Number of mines by mineral	County total
Adams	limestone (4)	4
Alexander	gannister (2); tripoli (4)[a]; clay[a]	6
Calhoun	clay (5)	5
Carroll	lead (2)	2
Du Page	dolomite (1)	1
Greene	limestone (1)	1
Hardin	fluorspar (130)[b]; lead (1)[b]; zinc[b]	131
Henderson	limestone (1)	1
Jackson	clay (1)	1
Jo Daviess	lead (93)[c]; zinc (9)[c]	102
Johnson	limestone (1)	1
La Salle	clay (6); limestone (2)	8
Livingston	clay (1)	1
McDonough	clay (3)	3
Madison	clay (2); limestone (2)	4
Marshall	clay (1)	1
Monroe	limestone (2)	2
Pike	limestone (3)	3
Pope	fluorspar (51)[d]; lead (7)[d]; zinc[d]; barite[d]	58
Randolph	limestone (3)	3
Rock Island	clay (1)	1
Saline	fluorspar (2)[e]; lead[e]	2
Scott	clay (1)	1
Union	clay (12); tripoli (2)	14

a two of the four tripoli mines also mined clay
b 29 of the fluorspar mines also produced lead, ten produced zinc, and four produced lead and zinc
c 54 of the lead mines also produced zinc
d 25 of the fluorspar mines also produced lead, three produced zinc, two produced lead and zinc, and one produced barite
e one fluorspar mine also produced lead

Table 3 Date of land-use data from U.S. Geological Survey files; map names refer to the USGS series of 1:250,000-scale maps.

Map name	Date of land use	Map name	Date of land use
Aurora	1978	Indianapolis	1972
Belleville	1980	Paducah	1973
Burlington	1974-75	Peoria	1978
Chicago	1975-78	Quincy	1969-76
Danville	1981	Racine	1978-81
Davenport	1976-81	Rockford	1978
Decatur	1973-76	Rolla	1972
Dubuque	1981	St. Louis	1972-76
Dyersburg	1973	Vincennes	1980-81

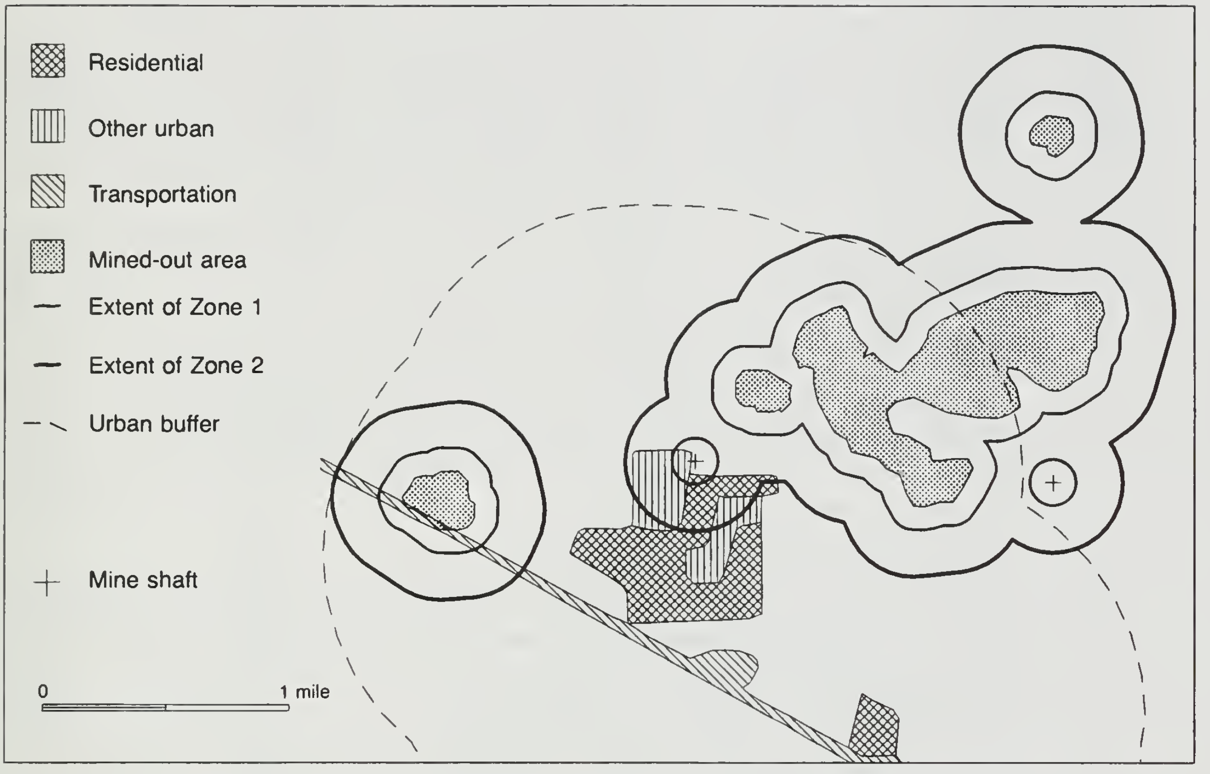

Figure 1 Schematic map showing the relationship of Zones 1 and 2 to mined-out areas and the relationship of urban buffer to urban land use.

Zones of Mine Proximity

The potential for mine subsidence in an area depends on many factors, but a key factor is the proximity of the area to underground mines. We used the GIS to define two zones around each mine (fig. 1). Zone 1 includes the land over or adjacent to mines that, on the basis of the mapped extent of the mine, could be affected by subsidence. Zone 2, which surrounds Zone 1, represents additional land that could be affected because of uncertainty about the exact location of the mine and the extent of its workings. These zones are associated only with known underground mines. Areas outside these two zones also could be undermined; old, undocumented mine openings have been discovered in many parts of the state, even in areas not known to contain minable deposits. Although the potential for subsidence exists in these places, most undocumented mines were prospect pits or short-term operations that undermined only a few acres.

Zone 1 is defined as the area directly over the mapped extent of the mines and adjacent land extending 500 feet beyond the mine boundaries. Land adjacent to a mine is included in this zone because subsidence resulting from the collapse of an underground mine can spread sideways as it moves upward to the land surface. Lateral propagation of subsidence, a function of the depth to the mine, the local geology, and other factors, is not highly predictable. The distance that subsidence can propagate laterally from a mine is generally much less than the depth from the land surface to the mine (Bauer and Hunt 1982). Most mines in Illinois and all mines in the state near major urban areas are less than 500 feet deep, so the lateral propagation of subsidence for most mines should be less than 500 feet; however, we assumed a conservative lateral distance of 500 feet for all mines.

Zone 2 represents areas outside the mapped extent of the mines but within a distance that could be affected by subsidence if the mine boundaries are inaccurate or uncertain. Uncertainties about the positions of mine boundaries arise from two sources: (1) incomplete or imprecise maps of mine workings and (2) errors in compilation and digitizing. We assumed that in all coal mines and in many industrial mineral and metal mines, errors from these two sources generally would not exceed 1,000 feet. For most mines, Zone 2 was defined as the area extending 1,000 feet beyond Zone 1. We expanded Zone 2 for industrial mineral and metal mines that we had located on the basis of small-scale source maps. When we had only a general location description (e.g., "3 miles west of town") for a mine, we centered Zone 2 on the approximate location indicated and enlarged it according to the size of the area in which the mine might be located (table 4).

Table 4 Width of Zone 2 assigned to industrial mineral and metal mines.

Source of mine outline or location	Width of Zone 2 (ft)
Original mine map, four reference points	1,000
Original mine map, registered using landmarks	1,000
Topographic map	1,000
Map with topography or with scale larger than 1:24,000	1,000
Map without topography and scale smaller than 1:24,000	2,320
Legal description with footages or good landmarks	1,000
Legal description of a 10-acre parcel within a section	1,660
Legal description of a 40-acre parcel within a section	2,320
Legal description of a 160-acre parcel within a section	3,640
Legal description of section only	6,280

Designation of an area as Zone 1 or Zone 2 cannot be directly translated into subsidence risk. Although the potential for mine subsidence is generally higher in Zone 1 than in the adjacent Zone 2, the potential for subsidence may be low in some areas designated Zone 1 and high in others. Other factors in addition to proximity to the mine (e.g., the geology of the roof and floor, the size and placement of the mine pillars, the depth of the mine, and previous subsidence at the site) help determine the potential for mine subsidence in an area. Precise estimates of the potential for subsidence cannot be made until the interaction of these factors is better understood.

Land-Use Categories

Four categories of land use were examined in this study: *residential, other urban, urban buffer,* and *non-urban*. The *urban buffer* areas were created using the GIS; the other three land-use categories were based on data obtained from the USGS.

The *residential* category in this study—identical to the residential land-use category in the USGS data set—consisted of predominantly residential areas of 10 acres or more. The *other urban* category consisted of land the USGS classified as industrial, commercial, industrial and commercial, mixed urban, transportation, and other urban. (We combined these USGS classes to simplify the reporting of the final statistics.) In some cases the *other urban* category includes land that may not contain major structures. For example, one large *other urban* area in Hamilton County is an oil-field water-flood operation, and some others in Jefferson County are surface facilities of underground coal mines. Urban areas smaller than 10 acres were not delineated in the USGS data set. The *nonurban* category, consisting of all land that was

neither urban or water, included croplands, forests, and pastures. Land classified by the USGS as transportation (highways, airports, and railroad yards) was included in our *nonurban* category because such land was unlikely to contain structures insured by the Illinois Mine Subsidence Insurance Fund. Bodies of water such as rivers, lakes, and reservoirs were not considered to be threatened by mine subsidence and were excluded from further study. The *urban buffer* category is a 1-mile zone surrounding all residential and urban land areas (fig. 1); mines in this zone could pose a subsidence risk for future urban expansion.

Number of Housing Units

We used data from the 1980 census to determine the number of housing units in a census division. Census divisions (tracts, block groups, or enumeration districts, depending on the county) were merged with the data on land use and mines and used to calculate the approximate number of homes in Zones 1 and 2. Because the actual distribution of housing units within a census division was not known, these calculations represent estimates, not actual counts of units. Our estimates reflect assumptions we made on the distribution of housing units and provide only a general assessment of the exposure of housing units to risk of mine subsidence.

We assumed that within a census division, 90 percent of the housing units would be evenly distributed across the areas classified as residential, and that the remaining 10 percent of the units would be distributed among all other categories (except water). In census divisions in which no areas were classified as residential, we assumed that housing units were evenly distributed throughout the area. These assumptions worked well for highly urbanized areas, rural areas with towns, and rural areas with no *residential* land. However, in dominantly rural townships with only small areas of residential land, this model assigned too many units to the residential areas. Therefore, for rural townships in which the 90/10 distribution of units produced anomalous results, we recalculated the numbers of units in Zones 1 and 2—assuming that units were evenly distributed across the township.

To test the sensitivity of the calculations to our assumption about the distribution of housing units, we made a second calculation, assuming that 75 percent of the units were in residential areas. On a statewide basis, calculations based on the 75/25 distribution yielded 16 percent fewer units in Zone 1 and 10 percent fewer units in Zone 2 than calculations based on the 90/10 distribution. In 8 percent of the townships there was no change when the 75/25 distribution was used, and in 12 percent of the townships the 75/25 distribution produced a higher estimate than did the 90/10 distribution.

We believe that the 90/10 distribution produces the best estimate of housing units in townships having major towns or cities—and it is these townships that are the primary focus of this study.

RESULTS

Statewide, approximately 109,000 acres of *residential* land and 69,000 acres of *other urban* land are close to underground mines and may be exposed to potential mine subsidence. Of this acreage, 125,000 acres are in Zone 1 and 53,000 acres are in Zone 2. An additional 877,000 acres (605,000 acres in Zone 1 and 272,000 acres in Zone 2) of potentially exposed land are within 1 mile of *residential* or *other urban* areas. More than 15 percent of the residential land in the 77 counties studied lies within Zone 1; on a county-by-county basis, this figure ranged from 0 to 77 percent of the residential land in a county. St. Clair County had the most *residential* land in Zone 1 (12,000 acres); this represents about 20 percent of the total *residential* acreage (79,000 acres) in the entire state that is in Zone 1 (fig. 2).

Figure 2 Residential acreage in Zone 1 (only counties having at least 100 acres of residential land in Zone 1 are shown).

Distribution of Undermined Land within Counties

The acreage of each county in Zone 1 and 2 (by land use category) is listed in tables 5 and 6. For example, in Bond County, 506 acres (27%) of the *residential* land is in Zone 1 (table 5), and 45 acres (2.4%) is in Zone 2 (table 6). The total acreage of Zones 1 and 2 in each county (by land-use category) and the estimated number of housing units in the two zones are given in table 7. Complete statistics by township are given in Treworgy et al. (1989).

Table 5 Acreage and percentage of land in Zone 1 by county and land use category (e.g., in Bond County the 506 acres of residential land in Zone 1 represents 27 percent of the total residential land in the county).

County	Residential acres (%)	Other urban acres (%)	Buffer acres (%)	Nonurban acres (%)	Total area acres (%)	Housing units units (%)
ADAMS	3 (0.0)	6 (0.1)	602 (0.5)	637 (0.1)	646 (0.1)	12 (0.0)
ALEXANDER	0 (0.0)	0 (0.0)	34 (0.1)	137 (0.1)	137 (0.1)	0 (0.0)
BOND	506 (27.0)	54 (4.6)	2,699 (4.5)	2,848 (1.2)	3,408 (1.4)	1,105 (17.3)
BROWN	0 (0.0)	0 (0.0)	33 (0.1)	360 (0.2)	360 (0.2)	0 (0.0)
BUREAU	1,352 (28.5)	780 (18.0)	7,443 (6.4)	9,458 (1.7)	11,590 (2.1)	3,371 (22.2)
CALHOUN	0 (0.0)	0 (0.0)	27 (0.1)	150 (0.1)	150 (0.1)	0 (0.0)
CARROLL	0 (0.0)	0 (0.0)	17 (0.0)	35 (0.0)	35 (0.0)	0 (0.0)
CASS	0 (0.0)	8 (0.8)	116 (0.4)	214 (0.1)	222 (0.1)	1 (0.0)
CHAMPAIGN	8 (0.1)	26 (0.2)	0 (0.0)	0 (0.0)	34 (0.0)	45 (0.1)
CHRISTIAN	3,155 (63.8)	2,567 (65.5)	26,430 (24.4)	55,830 (12.6)	61,552 (13.5)	8,864 (60.7)
CLINTON	1,171 (25.1)	960 (29.8)	11,856 (11.8)	15,646 (5.4)	17,777 (5.6)	3,064 (25.8)
COLES	17 (0.3)	0 (0.0)	0 (0.0)	17 (0.0)	34 (0.0)	59 (0.3)
CRAWFORD	9 (0.2)	17 (0.6)	185 (0.2)	219 (0.1)	245 (0.1)	15 (0.2)
CUMBERLAND	0 (0.0)	0 (0.0)	42 (0.1)	42 (0.0)	42 (0.0)	0 (0.0)
DOUGLAS	42 (1.8)	0 (0.0)	2,325 (3.6)	10,580 (4.1)	10,622 (4.0)	141 (1.8)
DU PAGE	151 (0.2)	53 (0.1)	66 (0.1)	66 (0.1)	270 (0.1)	552 (0.2)
EDGAR	0 (0.0)	0 (0.0)	66 (0.1)	1,394 (0.4)	1,394 (0.4)	9 (0.1)
EDWARDS	0 (0.0)	0 (0.0)	0 (0.0)	17 (0.0)	17 (0.0)	0 (0.0)
FRANKLIN	4,985 (69.9)	3,337 (68.1)	71,672 (62.6)	100,786 (39.9)	109,108 (39.5)	13,407 (70.8)
FULTON	1,092 (24.9)	850 (19.6)	18,596 (16.1)	41,636 (7.7)	43,578 (7.8)	4,024 (23.0)
GALLATIN	144 (12.1)	144 (29.2)	5,548 (18.0)	12,818 (6.2)	13,106 (6.2)	338 (10.6)
GREENE	16 (0.9)	0 (0.0)	480 (0.7)	1,713 (0.5)	1,729 (0.5)	55 (0.8)
GRUNDY	1,665 (39.8)	1,234 (11.7)	13,545 (14.0)	14,152 (5.5)	17,051 (6.2)	3,599 (31.2)
HAMILTON	0 (0.0)	572 (63.2)	1,630 (3.6)	1,632 (0.6)	2,204 (0.8)	11 (0.3)
HANCOCK	0 (0.0)	0 (0.0)	241 (0.3)	294 (0.1)	294 (0.1)	0 (0.0)
HARDIN	66 (10.2)	144 (30.1)	1,341 (4.8)	3,785 (3.4)	3,995 (3.5)	260 (10.5)
HENDERSON	0 (0.0)	0 (0.0)	17 (0.0)	17 (0.0)	17 (0.0)	0 (0.0)
HENRY	323 (4.1)	152 (3.4)	2,654 (1.9)	5,624 (1.1)	6,099 (1.2)	1,009 (4.7)
JACKSON	1,020 (16.0)	319 (11.8)	10,499 (9.3)	17,134 (4.7)	18,473 (4.8)	2,985 (12.2)
JASPER	0 (0.0)	0 (0.0)	88 (0.2)	140 (0.0)	140 (0.0)	0 (0.0)
JEFFERSON	515 (9.3)	1,255 (48.3)	13,785 (14.0)	25,179 (7.1)	26,949 (7.3)	1,303 (8.5)
JERSEY	0 (0.0)	0 (0.0)	52 (0.1)	160 (0.1)	160 (0.1)	0 (0.0)
JO DAVIESS	28 (1.5)	38 (1.1)	615 (1.1)	2,811 (0.7)	2,877 (0.7)	153 (1.6)
JOHNSON	0 (0.0)	4 (0.3)	266 (0.5)	450 (0.2)	454 (0.2)	0 (0.0)
KANKAKEE	0 (0.0)	33 (0.4)	426 (0.3)	563 (0.1)	596 (0.1)	0 (0.0)
KNOX	36 (0.5)	84 (1.1)	3,846 (3.1)	9,232 (2.1)	9,352 (2.0)	117 (0.5)
LA SALLE	4,789 (34.4)	2,510 (17.2)	10,343 (4.5)	11,455 (1.7)	18,754 (2.6)	15,606 (35.9)
LAWRENCE	0 (0.0)	0 (0.0)	432 (0.4)	579 (0.3)	579 (0.2)	0 (0.0)
LIVINGSTON	543 (12.7)	245 (6.3)	1,441 (1.0)	1,781 (0.3)	2,569 (0.4)	909 (6.1)
LOGAN	768 (22.9)	639 (24.2)	4,942 (5.4)	7,425 (1.9)	8,832 (2.3)	2,770 (23.0)
MCDONOUGH	25 (0.7)	45 (1.6)	1,076 (1.4)	2,685 (0.7)	2,755 (0.7)	125 (0.9)
MCLEAN	299 (2.5)	307 (2.6)	423 (0.2)	423 (0.1)	1,029 (0.1)	1,236 (2.7)
MACON	1,126 (6.9)	618 (7.8)	585 (0.6)	585 (0.2)	2,329 (0.6)	4,066 (7.9)
MACOUPIN	4,283 (60.1)	1,747 (56.5)	47,427 (31.8)	64,783 (12.1)	70,813 (12.9)	10,913 (54.3)
MADISON	7,023 (23.0)	2,317 (10.0)	27,415 (12.9)	32,374 (8.0)	41,714 (8.9)	17,186 (18.3)
MARION	2,016 (32.4)	590 (20.0)	6,815 (8.2)	7,077 (2.0)	9,683 (2.7)	5,029 (28.2)
MARSHALL	491 (29.6)	124 (6.2)	3,397 (7.0)	4,084 (1.7)	4,699 (1.8)	1,291 (22.7)
MENARD	110 (7.9)	12 (1.9)	2,629 (6.8)	4,151 (2.1)	4,273 (2.2)	312 (6.8)
MERCER	122 (3.8)	54 (3.0)	3,843 (4.7)	6,751 (1.9)	6,927 (1.9)	225 (3.0)
MONROE	0 (0.0)	13 (0.8)	494 (0.5)	545 (0.2)	558 (0.2)	5 (0.1)
MONTGOMERY	2,025 (43.3)	1,076 (34.0)	20,556 (21.1)	36,477 (8.4)	39,578 (8.9)	4,622 (35.8)
MORGAN	16 (0.4)	4 (0.1)	49 (0.1)	407 (0.1)	427 (0.1)	31 (0.2)
MOULTRIE	170 (13.3)	73 (7.8)	438 (0.9)	438 (0.2)	681 (0.3)	549 (10.0)
PEORIA	2,084 (10.1)	1,283 (8.1)	17,975 (12.0)	27,824 (7.8)	31,191 (7.8)	5,896 (7.4)
PERRY	1,578 (56.0)	452 (18.5)	21,034 (29.0)	28,467 (10.4)	30,497 (10.8)	4,426 (49.1)
PIKE	0 (0.0)	0 (0.0)	29 (0.0)	85 (0.0)	85 (0.0)	0 (0.0)
POPE	0 (0.0)	0 (0.0)	206 (0.5)	1,231 (0.5)	1,231 (0.5)	1 (0.1)
PUTNAM	320 (34.2)	172 (8.7)	2,039 (6.3)	2,097 (2.2)	2,589 (2.4)	675 (27.4)
RANDOLPH	1,074 (25.2)	918 (30.6)	18,595 (17.7)	30,431 (8.5)	32,423 (8.6)	2,246 (17.4)
ROCK ISLAND	735 (3.8)	84 (0.6)	3,291 (2.8)	3,396 (1.5)	4,215 (1.5)	1,903 (3.0)
ST CLAIR	12,033 (38.8)	3,885 (16.9)	40,665 (22.6)	50,231 (13.6)	66,149 (15.5)	33,893 (34.8)
SALINE	3,132 (77.4)	2,650 (63.9)	35,504 (46.3)	51,845 (22.1)	57,627 (23.6)	8,670 (70.4)
SANGAMON	10,016 (53.3)	6,578 (44.6)	43,114 (20.6)	56,750 (11.4)	73,344 (13.7)	37,600 (51.8)
SCHUYLER	0 (0.0)	31 (2.0)	305 (0.7)	1,656 (0.6)	1,687 (0.6)	4 (0.1)
SCOTT	0 (0.0)	15 (3.2)	253 (0.9)	350 (0.2)	365 (0.2)	0 (0.0)
SHELBY	304 (10.0)	82 (2.8)	1,124 (1.2)	3,154 (0.7)	3,540 (0.7)	816 (8.3)
STARK	0 (0.0)	0 (0.0)	90 (0.2)	272 (0.1)	272 (0.1)	0 (0.0)
TAZEWELL	1,795 (11.7)	598 (6.1)	3,696 (2.5)	3,789 (1.0)	6,182 (1.5)	5,125 (10.5)
UNION	0 (0.0)	0 (0.0)	0 (0.0)	222 (0.1)	222 (0.1)	0 (0.0)
VERMILION	1,278 (13.5)	1,208 (15.5)	20,581 (14.7)	33,347 (6.0)	35,833 (6.3)	5,250 (13.7)
WABASH	86 (2.8)	54 (3.3)	3,002 (4.2)	5,496 (4.0)	5,636 (3.9)	89 (1.6)
WARREN	0 (0.0)	0 (0.0)	38 (0.1)	640 (0.2)	640 (0.2)	1 (0.0)
WASHINGTON	186 (7.4)	186 (27.2)	5,486 (7.5)	7,273 (2.1)	7,645 (2.1)	550 (8.8)
WHITE	28 (1.0)	0 (0.0)	632 (1.1)	1,931 (0.6)	1,959 (0.6)	72 (0.9)
WILL	549 (1.7)	768 (1.8)	2,829 (1.0)	2,887 (0.6)	4,204 (0.8)	887 (0.8)
WILLIAMSON	3,932 (45.7)	3,910 (25.2)	53,451 (37.8)	75,275 (30.5)	83,117 (29.5)	10,653 (43.9)
WOODFORD	190 (4.6)	287 (10.7)	1,988 (2.2)	2,055 (0.6)	2,532 (0.7)	617 (5.2)
TOTAL	79,430 (15.5)	46,172 (10.8)	605,474 (8.5)	908,500 (3.5)	1,034,102 (3.8)	228,748 (13.4)

Table 6 Acreage and percentage of land in Zone 2 by county and land use category (e.g. in Bond County the 45 acres of residential land in Zone 1 represents 2.4 percent of the total residential land in the county.

County	Residential acres (%)	Other urban acres (%)	Buffer acres (%)	Nonurban acres (%)	Total area acres (%)	Housing units units (%)
ADAMS	92 (1.2)	75 (1.6)	886 (0.7)	1,139 (0.2)	1,306 (0.2)	390 (1.4)
ALEXANDER	11 (1.0)	0 (0.0)	1,811 (4.1)	6,480 (4.4)	6,491 (4.0)	56 (1.1)
BOND	45 (2.4)	2 (0.2)	1,777 (3.0)	2,180 (0.9)	2,227 (0.9)	89 (1.4)
BROWN	0 (0.0)	0 (0.0)	182 (0.7)	2,625 (1.4)	2,625 (1.4)	7 (0.3)
BUREAU	58 (1.2)	429 (9.9)	4,645 (4.0)	7,577 (1.4)	8,064 (1.4)	199 (1.3)
CALHOUN	0 (0.0)	0 (0.0)	199 (0.5)	1,543 (1.0)	1,543 (0.9)	3 (0.1)
CARROLL	0 (0.0)	0 (0.0)	96 (0.2)	695 (0.2)	695 (0.2)	3 (0.0)
CASS	26 (1.7)	46 (4.7)	773 (2.4)	1,553 (0.7)	1,625 (0.7)	72 (1.2)
CHAMPAIGN	137 (1.0)	106 (0.7)	41 (0.0)	41 (0.0)	284 (0.0)	567 (0.9)
CHRISTIAN	503 (10.2)	268 (6.8)	5,649 (5.2)	12,542 (2.8)	13,313 (2.9)	1,311 (9.0)
CLINTON	698 (14.9)	463 (14.4)	4,690 (4.7)	7,559 (2.6)	8,720 (2.7)	1,675 (14.1)
COLES	75 (1.5)	54 (2.1)	0 (0.0)	156 (0.0)	285 (0.1)	265 (1.3)
CRAWFORD	9 (0.2)	83 (3.1)	760 (0.6)	1,023 (0.4)	1,115 (0.4)	16 (0.2)
CUMBERLAND	0 (0.0)	13 (3.4)	242 (0.8)	242 (0.1)	255 (0.1)	1 (0.0)
DOUGLAS	3 (0.1)	0 (0.0)	457 (0.7)	2,967 (1.1)	2,970 (1.1)	15 (0.2)
DU PAGE	270 (0.4)	105 (0.2)	18 (0.0)	18 (0.0)	393 (0.2)	954 (0.4)
EDGAR	0 (0.0)	0 (0.0)	377 (0.5)	2,821 (0.7)	2,821 (0.7)	17 (0.2)
EDWARDS	0 (0.0)	0 (0.0)	0 (0.0)	97 (0.1)	97 (0.1)	0 (0.0)
FRANKLIN	703 (9.9)	397 (8.1)	5,644 (4.9)	11,473 (4.5)	12,573 (4.6)	1,799 (9.5)
FULTON	1,300 (29.6)	964 (22.3)	15,570 (13.5)	50,657 (9.4)	52,921 (9.5)	4,787 (27.3)
GALLATIN	216 (18.1)	74 (15.0)	2,811 (9.1)	11,514 (5.6)	11,804 (5.6)	464 (14.5)
GREENE	62 (3.5)	30 (2.8)	1,062 (1.6)	5,041 (1.5)	5,133 (1.5)	212 (3.1)
GRUNDY	609 (14.5)	1,196 (11.3)	8,401 (8.7)	9,231 (3.6)	11,036 (4.0)	1,982 (17.2)
HAMILTON	0 (0.0)	9 (1.0)	1,136 (2.5)	1,198 (0.4)	1,207 (0.4)	4 (0.1)
HANCOCK	0 (0.0)	10 (0.6)	971 (1.2)	1,348 (0.3)	1,358 (0.3)	2 (0.0)
HARDIN	177 (27.5)	144 (30.1)	4,008 (14.5)	12,971 (11.6)	13,292 (11.6)	514 (20.8)
HENDERSON	0 (0.0)	0 (0.0)	539 (1.1)	552 (0.2)	552 (0.2)	0 (0.0)
HENRY	459 (5.8)	350 (7.9)	5,963 (4.3)	12,135 (2.4)	12,944 (2.5)	1,325 (6.1)
JACKSON	774 (12.1)	43 (1.6)	6,169 (5.5)	12,860 (3.5)	13,677 (3.6)	2,433 (9.9)
JASPER	0 (0.0)	0 (0.0)	440 (0.8)	790 (0.3)	790 (0.3)	0 (0.0)
JEFFERSON	277 (5.0)	127 (4.9)	2,090 (2.1)	5,663 (1.6)	6,067 (1.6)	575 (3.7)
JERSEY	0 (0.0)	0 (0.0)	396 (0.7)	1,017 (0.4)	1,017 (0.4)	3 (0.0)
JO DAVIESS	302 (16.4)	152 (4.4)	5,926 (10.5)	23,850 (6.2)	24,304 (6.2)	1,251 (12.9)
JOHNSON	0 (0.0)	44 (2.9)	729 (1.3)	1,730 (0.8)	1,774 (0.8)	1 (0.0)
KANKAKEE	0 (0.0)	1 (0.0)	548 (0.3)	960 (0.2)	961 (0.2)	1 (0.0)
KNOX	160 (2.2)	138 (1.8)	5,465 (4.4)	15,430 (3.5)	15,728 (3.4)	342 (1.4)
LA SALLE	1,021 (7.3)	1,233 (8.4)	10,450 (4.5)	13,313 (1.9)	15,567 (2.1)	3,164 (7.3)
LAWRENCE	26 (0.5)	0 (0.0)	297 (0.3)	776 (0.3)	802 (0.3)	54 (0.7)
LIVINGSTON	230 (5.4)	219 (5.6)	2,673 (1.9)	3,210 (0.5)	3,659 (0.5)	680 (4.5)
LOGAN	451 (13.4)	402 (15.2)	2,551 (2.8)	4,039 (1.0)	4,892 (1.2)	1,566 (13.0)
MCDONOUGH	119 (3.6)	57 (2.0)	2,784 (3.7)	8,974 (2.5)	9,150 (2.5)	441 (3.2)
MCLEAN	381 (3.2)	101 (0.8)	830 (0.4)	830 (0.1)	1,312 (0.2)	1,558 (3.4)
MACON	816 (5.0)	281 (3.5)	641 (0.6)	641 (0.2)	1,738 (0.5)	2,902 (5.6)
MACOUPIN	551 (7.7)	510 (16.5)	11,759 (7.9)	21,965 (4.1)	23,026 (4.2)	1,669 (8.3)
MADISON	3,310 (10.8)	1,602 (6.9)	14,995 (7.1)	17,974 (4.4)	22,886 (4.9)	9,052 (9.7)
MARION	504 (8.1)	197 (6.7)	3,064 (3.7)	3,122 (0.9)	3,823 (1.1)	1,454 (8.2)
MARSHALL	149 (9.0)	42 (2.1)	3,536 (7.2)	5,772 (2.4)	5,963 (2.3)	295 (5.2)
MENARD	272 (19.4)	164 (26.2)	3,708 (9.6)	6,083 (3.1)	6,519 (3.3)	761 (16.5)
MERCER	206 (6.5)	42 (2.4)	3,295 (4.0)	9,777 (2.8)	10,025 (2.8)	424 (5.6)
MONROE	2 (0.1)	28 (1.8)	881 (0.9)	1,914 (0.8)	1,944 (0.8)	16 (0.2)
MONTGOMERY	802 (17.1)	424 (13.4)	5,882 (6.0)	14,013 (3.2)	15,239 (3.4)	2,055 (15.9)
MORGAN	75 (1.9)	19 (0.5)	484 (0.6)	2,358 (0.7)	2,452 (0.7)	150 (1.0)
MOULTRIE	38 (3.0)	0 (0.0)	541 (1.1)	541 (0.3)	579 (0.3)	123 (2.2)
PEORIA	1,064 (5.2)	856 (5.4)	11,875 (8.0)	22,651 (6.3)	24,571 (6.2)	3,601 (4.5)
PERRY	831 (29.5)	416 (17.0)	8,693 (12.0)	18,035 (6.6)	19,282 (6.9)	1,917 (21.3)
PIKE	0 (0.0)	0 (0.0)	216 (0.2)	485 (0.1)	485 (0.1)	0 (0.0)
POPE	140 (34.4)	127 (22.4)	2,976 (6.8)	14,114 (6.0)	14,381 (6.0)	464 (24.0)
PUTNAM	49 (5.2)	51 (2.6)	1,539 (4.8)	1,603 (1.7)	1,703 (1.6)	171 (6.9)
RANDOLPH	496 (11.6)	211 (7.0)	5,621 (5.4)	15,136 (4.2)	15,843 (4.2)	1,178 (9.1)
ROCK ISLAND	907 (4.7)	469 (3.2)	5,013 (4.2)	5,323 (2.3)	6,699 (2.4)	2,749 (4.3)
ST CLAIR	3,565 (11.5)	2,037 (8.9)	17,113 (9.5)	22,777 (6.2)	28,379 (6.7)	10,949 (11.2)
SALINE	402 (9.9)	918 (22.2)	8,534 (11.1)	21,673 (9.2)	22,993 (9.4)	1,269 (10.3)
SANGAMON	2,390 (12.7)	1,553 (10.5)	14,763 (7.0)	21,582 (4.3)	25,525 (4.8)	9,198 (12.7)
SCHUYLER	44 (6.0)	203 (12.9)	1,618 (3.7)	9,367 (3.4)	9,614 (3.4)	209 (5.8)
SCOTT	23 (3.1)	39 (8.4)	846 (2.9)	1,567 (1.0)	1,629 (1.0)	67 (3.0)
SHELBY	185 (6.1)	169 (5.9)	3,684 (4.0)	8,547 (1.8)	8,901 (1.8)	537 (5.4)
STARK	9 (0.8)	0 (0.0)	540 (1.4)	1,866 (1.0)	1,875 (1.0)	21 (0.7)
TAZEWELL	934 (6.1)	461 (4.7)	2,001 (1.3)	2,137 (0.6)	3,532 (0.8)	2,905 (5.9)
UNION	0 (0.0)	0 (0.0)	209 (0.4)	4,018 (1.5)	4,018 (1.5)	14 (0.2)
VERMILION	965 (10.2)	666 (8.6)	9,368 (6.7)	16,809 (3.0)	18,440 (3.2)	4,221 (11.0)
WABASH	114 (3.7)	56 (3.4)	3,493 (4.8)	5,178 (3.8)	5,348 (3.7)	145 (2.5)
WARREN	0 (0.0)	0 (0.0)	339 (0.6)	2,860 (0.8)	2,860 (0.8)	6 (0.1)
WASHINGTON	287 (11.5)	135 (19.8)	2,363 (3.2)	3,899 (1.1)	4,321 (1.2)	639 (10.2)
WHITE	91 (3.2)	0 (0.0)	472 (0.8)	1,409 (0.5)	1,500 (0.5)	229 (2.9)
WILL	245 (0.8)	776 (1.8)	2,266 (0.8)	2,410 (0.5)	3,431 (0.6)	390 (0.4)
WILLIAMSON	758 (8.8)	3,216 (20.7)	8,746 (6.2)	17,571 (7.1)	21,545 (7.6)	2,054 (8.5)
WOODFORD	84 (2.0)	83 (3.1)	1,069 (1.2)	1,306 (0.4)	1,473 (0.4)	226 (1.9)
TOTAL	29,502 (5.8)	23,086 (5.4)	272,199 (3.8)	567,303 (2.2)	619,891 (2.3)	90,858 (5.3)

Table 7 Acreage and percentage of land in Zone 1 and 2 by county and land use category (e.g. in Bond County the 551 acres of residential land in Zones 1 and 2 represents 29.4 percent of the total residential land in the county.

County	Residential acres (%)	Other urban acres (%)	Buffer acres (%)	Nonurban acres (%)	Total area acres (%)	Housing units units (%)
ADAMS	95 (1.3)	81 (1.8)	1,488 (1.1)	1,776 (0.3)	1,952 (0.4)	402 (1.4)
ALEXANDER	11 (1.0)	0 (0.0)	1,845 (4.2)	6,617 (4.5)	6,628 (4.1)	56 (1.1)
BOND	551 (29.4)	56 (4.8)	4,476 (7.5)	5,028 (2.1)	5,635 (2.3)	1,194 (18.7)
BROWN	0 (0.0)	0 (0.0)	215 (0.8)	2,985 (1.6)	2,985 (1.5)	7 (0.3)
BUREAU	1,410 (29.7)	1,209 (27.9)	12,088 (10.5)	17,035 (3.1)	19,654 (3.5)	3,570 (23.5)
CALHOUN	0 (0.0)	0 (0.0)	226 (0.6)	1,693 (1.1)	1,693 (0.9)	3 (0.1)
CARROLL	0 (0.0)	0 (0.0)	113 (0.2)	730 (0.3)	730 (0.2)	3 (0.0)
CASS	26 (1.7)	54 (5.5)	889 (2.8)	1,767 (0.7)	1,847 (0.8)	73 (1.2)
CHAMPAIGN	145 (1.1)	132 (0.8)	41 (0.0)	41 (0.0)	318 (0.1)	612 (1.0)
CHRISTIAN	3,658 (73.9)	2,835 (72.4)	32,079 (29.6)	68,372 (15.5)	74,865 (16.5)	10,175 (69.7)
CLINTON	1,869 (40.0)	1,423 (44.2)	16,546 (16.5)	23,205 (7.9)	26,497 (8.3)	4,739 (39.8)
COLES	92 (1.9)	54 (2.1)	0 (0.0)	173 (0.1)	319 (0.1)	324 (1.6)
CRAWFORD	18 (0.4)	100 (3.7)	945 (0.8)	1,242 (0.5)	1,360 (0.5)	31 (0.4)
CUMBERLAND	0 (0.0)	13 (3.4)	284 (0.9)	284 (0.1)	297 (0.1)	1 (0.0)
DOUGLAS	45 (1.9)	0 (0.0)	2,782 (4.3)	13,547 (5.2)	13,592 (5.2)	156 (2.0)
DU PAGE	42 (0.6)	158 (0.3)	84 (0.1)	84 (0.1)	663 (0.3)	1,506 (0.6)
EDGAR	0 (0.0)	0 (0.0)	443 (0.6)	4,215 (1.1)	4,215 (1.1)	26 (0.3)
EDWARDS	0 (0.0)	0 (0.0)	0 (0.0)	114 (0.1)	114 (0.1)	0 (0.0)
FRANKLIN	5,688 (79.8)	3,734 (76.2)	77,316 (67.5)	112,259 (44.5)	121,681 (44.1)	15,206 (80.3)
FULTON	2,392 (54.5)	1,814 (41.9)	34,166 (29.6)	92,293 (17.0)	96,499 (17.2)	8,811 (50.3)
GALLATIN	360 (30.2)	218 (44.2)	8,359 (27.2)	24,332 (11.8)	24,910 (11.8)	802 (25.1)
GREENE	78 (4.4)	30 (2.8)	1,542 (2.3)	6,754 (2.0)	6,862 (2.0)	267 (3.9)
GRUNDY	2,274 (54.3)	2,430 (23.0)	21,946 (22.7)	23,383 (9.2)	28,087 (10.3)	5,581 (48.4)
HAMILTON	0 (0.0)	581 (64.2)	2,766 (6.1)	2,830 (1.0)	3,411 (1.2)	15 (0.4)
HANCOCK	0 (0.0)	10 (0.6)	1,212 (1.5)	1,642 (0.3)	1,652 (0.3)	2 (0.0)
HARDIN	243 (37.7)	288 (60.3)	5,349 (19.3)	16,756 (15.0)	17,287 (15.0)	774 (31.3)
HENDERSON	0 (0.0)	0 (0.0)	556 (1.1)	569 (0.2)	569 (0.2)	0 (0.0)
HENRY	782 (10.0)	502 (11.3)	8,617 (6.2)	17,759 (3.5)	19,043 (3.6)	2,334 (10.8)
JACKSON	1,794 (28.1)	362 (13.4)	16,668 (14.8)	29,994 (8.2)	32,150 (8.4)	5,418 (22.1)
JASPER	0 (0.0)	0 (0.0)	528 (1.0)	930 (0.3)	930 (0.3)	0 (0.0)
JEFFERSON	792 (14.3)	1,382 (53.2)	15,875 (16.1)	30,842 (8.7)	33,016 (9.0)	1,878 (12.2)
JERSEY	0 (0.0)	0 (0.0)	448 (0.8)	1,177 (0.5)	1,177 (0.5)	3 (0.0)
JO DAVIESS	330 (17.9)	190 (5.6)	6,541 (11.5)	26,661 (7.0)	27,181 (6.9)	1,404 (14.5)
JOHNSON	0 (0.0)	48 (3.1)	995 (1.8)	2,180 (1.0)	2,228 (1.0)	1 (0.0)
KANKAKEE	0 (0.0)	34 (0.4)	974 (0.6)	1,523 (0.4)	1,557 (0.4)	1 (0.0)
KNOX	196 (2.7)	222 (2.9)	9,311 (7.6)	24,662 (5.6)	25,080 (5.5)	459 (1.9)
LA SALLE	5,810 (41.7)	3,743 (25.6)	20,793 (9.0)	24,768 (3.6)	34,321 (4.7)	18,770 (43.1)
LAWRENCE	26 (0.5)	0 (0.0)	729 (0.7)	1,355 (0.6)	1,381 (0.6)	54 (0.7)
LIVINGSTON	773 (18.1)	464 (11.9)	4,114 (2.9)	4,991 (0.8)	6,228 (0.9)	1,589 (10.6)
LOGAN	1,219 (36.3)	1,041 (39.4)	7,493 (8.2)	11,464 (3.0)	13,724 (3.5)	4,336 (36.0)
MCDONOUGH	144 (4.3)	102 (3.6)	3,860 (5.1)	11,659 (3.2)	11,905 (3.2)	566 (4.1)
MCLEAN	680 (5.8)	408 (3.4)	1,253 (0.7)	1,253 (0.2)	2,341 (0.3)	2,794 (6.2)
MACON	1,942 (11.8)	899 (11.3)	1,226 (1.2)	1,226 (0.4)	4,067 (1.1)	6,968 (13.5)
MACOUPIN	4,834 (67.8)	2,257 (72.9)	59,186 (39.7)	86,748 (16.2)	93,839 (17.1)	12,582 (62.7)
MADISON	10,333 (33.8)	3,919 (16.9)	42,410 (20.0)	50,348 (12.4)	64,600 (13.8)	26,238 (28.0)
MARION	2,520 (40.5)	787 (26.7)	9,879 (11.9)	10,199 (2.9)	13,506 (3.7)	6,483 (36.4)
MARSHALL	640 (38.6)	166 (8.3)	6,933 (14.2)	9,856 (4.0)	10,662 (4.2)	1,586 (27.9)
MENARD	382 (27.3)	176 (28.1)	6,337 (16.4)	10,234 (5.2)	10,792 (5.4)	1,073 (23.3)
MERCER	328 (10.3)	96 (5.4)	7,138 (8.7)	16,528 (4.7)	16,952 (4.7)	649 (8.5)
MONROE	2 (0.1)	41 (2.6)	1,375 (1.4)	2,459 (1.0)	2,502 (1.0)	21 (0.3)
MONTGOMERY	2,827 (60.4)	1,500 (47.3)	26,438 (27.1)	50,490 (11.6)	54,817 (12.3)	6,677 (51.7)
MORGAN	91 (2.3)	23 (0.6)	533 (0.7)	2,765 (0.8)	2,879 (0.8)	181 (1.2)
MOULTRIE	208 (16.2)	73 (7.8)	979 (2.0)	979 (0.5)	1,260 (0.6)	672 (12.2)
PEORIA	3,148 (15.3)	2,139 (13.5)	29,850 (20.0)	50,475 (14.1)	55,762 (14.0)	9,497 (12.0)
PERRY	2,409 (85.4)	868 (35.5)	29,727 (41.0)	46,502 (17.0)	49,779 (17.7)	6,343 (70.4)
PIKE	0 (0.0)	0 (0.0)	245 (0.3)	570 (0.1)	570 (0.1)	0 (0.0)
POPE	140 (34.4)	127 (22.4)	3,182 (7.3)	15,345 (6.5)	15,612 (6.5)	465 (24.1)
PUTNAM	369 (39.5)	223 (11.3)	3,578 (11.1)	3,700 (3.8)	4,292 (4.0)	846 (34.4)
RANDOLPH	1,570 (36.9)	1,129 (37.6)	24,216 (23.1)	45,567 (12.7)	48,266 (12.8)	3,424 (26.5)
ROCK ISLAND	1,642 (8.6)	553 (3.8)	8,304 (7.0)	8,719 (3.8)	10,914 (3.9)	4,652 (7.3)
ST CLAIR	15,598 (50.3)	5,922 (25.8)	57,778 (32.0)	73,008 (19.8)	94,528 (22.2)	44,842 (46.0)
SALINE	3,534 (87.3)	3,568 (86.1)	44,038 (57.5)	73,518 (31.3)	80,620 (33.0)	9,939 (80.7)
SANGAMON	12,406 (66.0)	8,131 (55.1)	57,877 (27.6)	78,332 (15.7)	98,869 (18.5)	46,798 (64.5)
SCHUYLER	44 (6.0)	234 (14.9)	1,923 (4.4)	11,023 (4.0)	11,301 (4.0)	213 (5.9)
SCOTT	23 (3.1)	54 (11.6)	1,099 (3.8)	1,917 (1.2)	1,994 (1.3)	67 (3.0)
SHELBY	489 (16.1)	251 (8.7)	4,808 (5.3)	11,701 (2.5)	12,441 (2.6)	1,353 (13.7)
STARK	9 (0.8)	0 (0.0)	630 (1.7)	2,138 (1.2)	2,147 (1.2)	21 (0.7)
TAZEWELL	2,729 (17.8)	1,059 (10.9)	5,697 (3.8)	5,926 (1.5)	9,714 (2.3)	8,030 (16.4)
UNION	0 (0.0)	0 (0.0)	209 (0.4)	4,240 (1.6)	4,240 (1.6)	14 (0.2)
VERMILION	2,243 (23.6)	1,874 (24.1)	29,949 (21.4)	50,156 (9.1)	54,273 (9.5)	9,471 (24.7)
WABASH	200 (6.4)	110 (6.6)	6,495 (9.0)	10,674 (7.8)	10,984 (7.6)	234 (4.1)
WARREN	0 (0.0)	0 (0.0)	377 (0.6)	3,500 (1.0)	3,500 (1.0)	7 (0.1)
WASHINGTON	473 (18.9)	321 (47.0)	7,849 (10.7)	11,172 (3.2)	11,966 (3.3)	1,189 (19.0)
WHITE	119 (4.2)	0 (0.0)	1,104 (1.9)	3,340 (1.1)	3,459 (1.1)	301 (3.8)
WILL	794 (2.5)	1,544 (3.6)	5,095 (1.8)	5,297 (1.2)	7,635 (1.4)	1,277 (1.2)
WILLIAMSON	4,690 (54.5)	7,126 (45.8)	62,197 (44.0)	92,846 (37.6)	104,662 (37.1)	12,710 (52.4)
WOODFORD	274 (6.7)	370 (13.8)	3,057 (3.5)	3,361 (1.0)	4,005 (1.2)	843 (7.1)
TOTAL	108,932 (21.3)	69,258 (16.2)	877,673 (12.3)	1,475,803 (5.8)	1,653,993 (6.1)	319,609 (18.8)

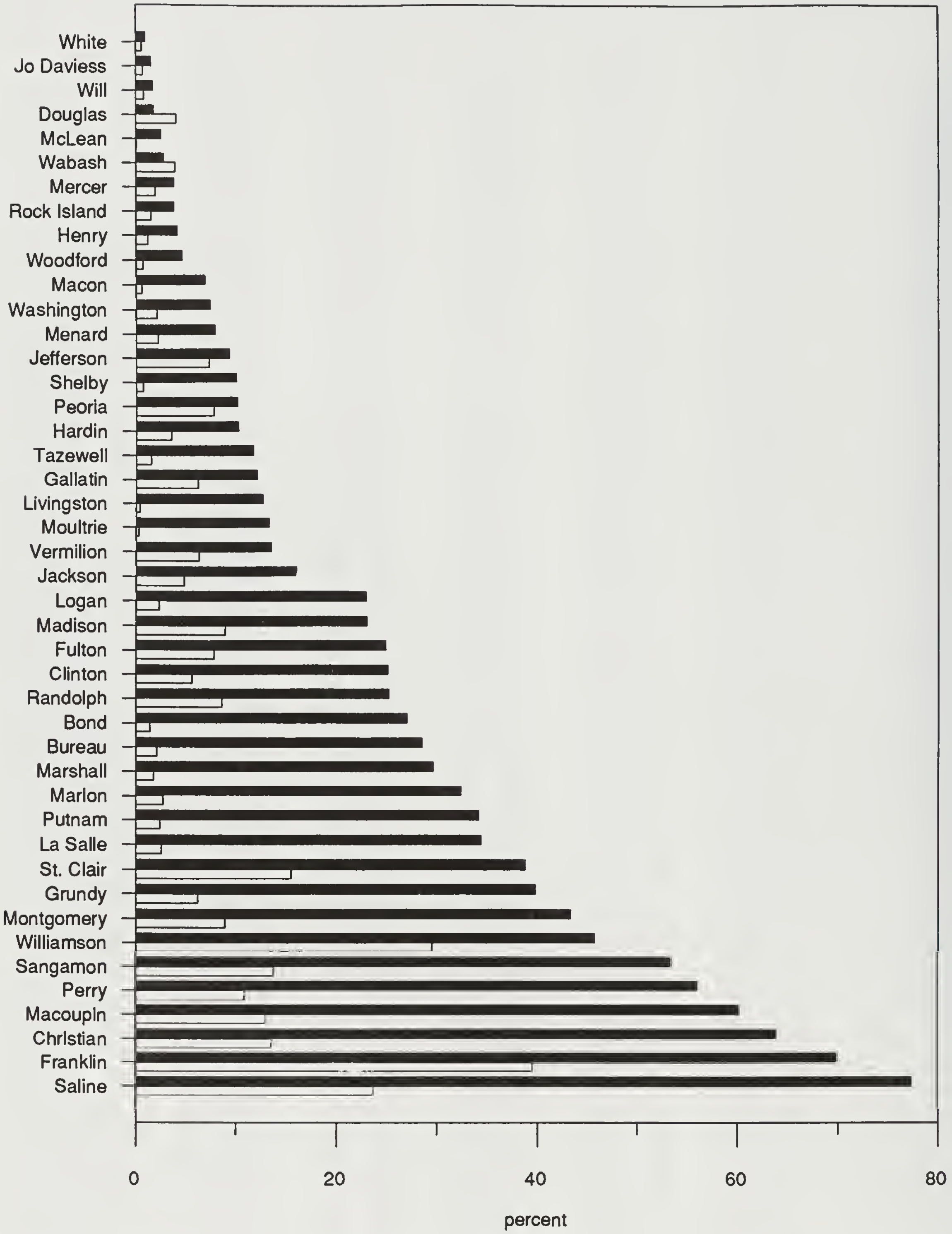

Figure 3 Comparison (by county) of percentage of total area in Zone 1 (white bar) with the percentage of residential land in Zone 1 (black bar). Only counties having a minimum of 1 percent of residential land in Zone 1 are shown.

Table 8 Ranking of the top 15 counties by total acreage in Zone 1 and the estimated number of housing units in Zone 1.

	County	Acreage in Zone 1		County	Housing units in Zone 1
1	Franklin	109,108	1	Sangamon	37,600
2	Williamson	83,117	2	St. Clair	33,893
3	Sangamon	73,344	3	Madison	17,186
4	Macoupin	70,813	4	LaSalle	15,606
5	St. Clair	66,149	5	Franklin	13,407
6	Christian	61,552	6	Macoupin	10,913
7	Saline	57,627	7	Williamson	10,653
8	Fulton	43,578	8	Christian	8,864
9	Madison	41,714	9	Saline	8,670
10	Montgomery	39,578	10	Peoria	5,896
11	Vermilion	35,833	11	Vermilion	5,250
12	Randolph	32,423	12	Tazewell	5,125
13	Peoria	31,191	13	Marion	5,029
14	Perry	30,497	14	Montgomery	4,622
15	Jefferson	26,949	15	Perry	4,426

Because the oldest mining operations in the state were generally located in and around populated areas, urban areas often have disproportionably higher percentages of undermined land than do adjacent rural areas. In 53 of the 77 counties studied, the percentage of residential land in Zone 1 per county is higher (often significantly higher) than the percentage of the total county area in Zone 1. Figure 3 compares the percentage of residential land in Zone 1 in each county with the percentage of total land in the county in Zone 1 (for all counties in which at least 1 percent of the residential land is in Zone 1). Two factors explain the high percentages of residential land in Zone 1: (1) mines were often intentionally located in and around towns because the towns served both as a source of labor and a market for the coal, and (2) some mines were started along railroad lines to supply passing trains, and towns then grew up around the mines. For example, in Macon County less than 1 percent of the land is undermined, but most of the mines are located under or adjacent to developed areas (figs. 3, 4). About 7 percent of the residential land in Macon County is in Zone 1 (table 5), and an additional 5 percent of residential land is in Zone 2. Approximately 7,000 housing units in Zones 1 and 2 are over or adjacent to underground mines and thus are exposed to some subsidence risk. More than 4,000 of these housing units are in Zone 1 (table 5).

In 24 of the 77 counties studied, the percentage of the urban land in Zones 1 and 2 was less than the percentage of the total county area in Zones 1 and 2. For example, more than 5 percent of Douglas County was in Zone 1 and 2, but less than 2 percent of the residential area in the county was in these zones (table 7). In 17 counties with underground mines (Alexander, Brown, Calhoun, Carroll, Cumberland, Edgar, Edwards, Hancock, Henderson, Jasper, Jersey, Lawrence, Pike, Pope, Stark, Union, and Warren) no urban land was in Zones 1 and 2.

The magnitude of potential mine subsidence damage to structures in a county is related to the amount of development over underground mines. Compare, for instance, the ranking of counties by total acreage in Zone 1 to the ranking of counties by estimated number of housing units in Zone 1 (table 8). Franklin County had by far the most total acreage in Zone 1, but because the county has no major urban development it had significantly fewer housing units in Zone 1 than did four counties having large urban areas. La Salle County, which ranked 16th in acreage in Zone 1 (less than one-fifth the Zone 1 acreage of Franklin County), ranked ahead of Franklin County in number of housing units in Zone 1.

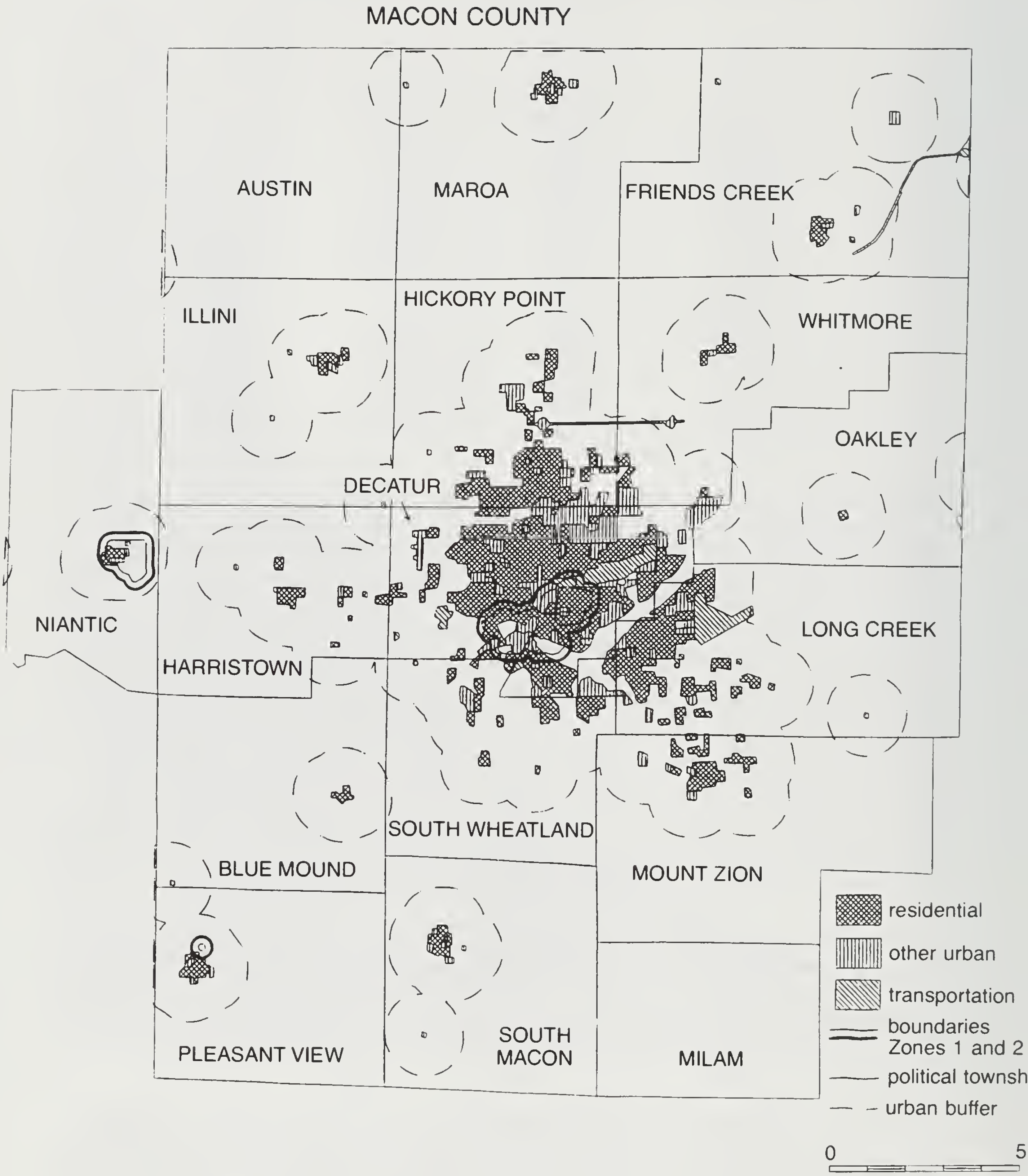

Figure 4 Undermined lands and built-up areas in Macon County (see also figure 3).

Table 9 Counties with longwall mining (based on Guither et al. 1984).

County	Number of longwall mines	Total number of mines
Bureau	9	47
Christian	1	16
Franklin	6*	35
Grundy	36	204
Hamilton	1*	1
Jefferson	3*	9
La Salle	22	346
Livingston	3	62
Logan	1	7
McLean	1	4
Macon	2	5
Macoupin	3	84
Marshall	4	56
Montgomery	1	16
Peoria	1	234
Putnam	4	4
Will	17	48
Williamson	1*	310
Woodford	2	5

*includes mines that used high-extraction-retreat room and pillar methods

Effect of Mining Method on Subsidence Potential

Factors other than proximity to mines must be considered in assessing the potential risk of subsidence in an area. For instance, the mining method used determines the amount of coal left in the mine as pillars to support the overburden. Some form of room and pillar mining—in which 40 to 60 percent of the coal is commonly left in place to support the mine roof—was used in most Illinois mines. Over time, these pillars of coal may fail; however, it is generally impossible to predict when, if ever, failure will occur. Two other mining techniques used in Illinois are longwall mining and high-extraction room and pillar mining. Miners using these techniques remove most or all of the coal from sections of the mine, causing subsidence of the ground surface to occur shortly after mining. Once ground movement ceases there is no future risk of subsidence over these sections of the mine.

For example, a type of longwall mining method was used in parts of the mines underlying the city of Decatur in Macon County (the large urban area in the center of figure 4). Most subsidence associated with this mining method occurred within a few years of mining; therefore the risk of future subsidence over the parts of these mines in which longwall methods were used is now negligible. The effects of specific mining methods on the potential for subsidence must be evaluated on a site-by-site basis; these effects were not considered in this study. Longwall methods have been used in only a small percentage of the more than 2,660 mines in Illinois. Table 9 lists the number of longwall mines in each county.

The interaction of other factors that contribute to the potential for subsidence (for example, the geology of the roof and floor, depth of the mine, and previous subsidence at the site) is not well understood and too complex to include in this study. These factors should be considered when evaluating the potential for subsidence at specific sites.

Potential Impact of Subsidence on Urban Expansion

The *urban buffer* category identifies locations where mined-out areas are adjacent to residential or other urban land, and subsidence could affect future construction and commercial development. For example, about 8 percent of Peoria County (including 10% of its residential acreage) is in Zone 1. However, an even larger percentage of *urban buffer* land (12%) is in Zone 1, indicating that the overall exposure to subsidence risk may increase as urban areas in Peoria County expand. This statistic is even more dramatic when individual townships are examined: much less than 1 percent of the city of Peoria is in Zone 1, but in the three townships south and west of the city almost 32 percent of the urban buffer is in Zone 1 (fig. 5).

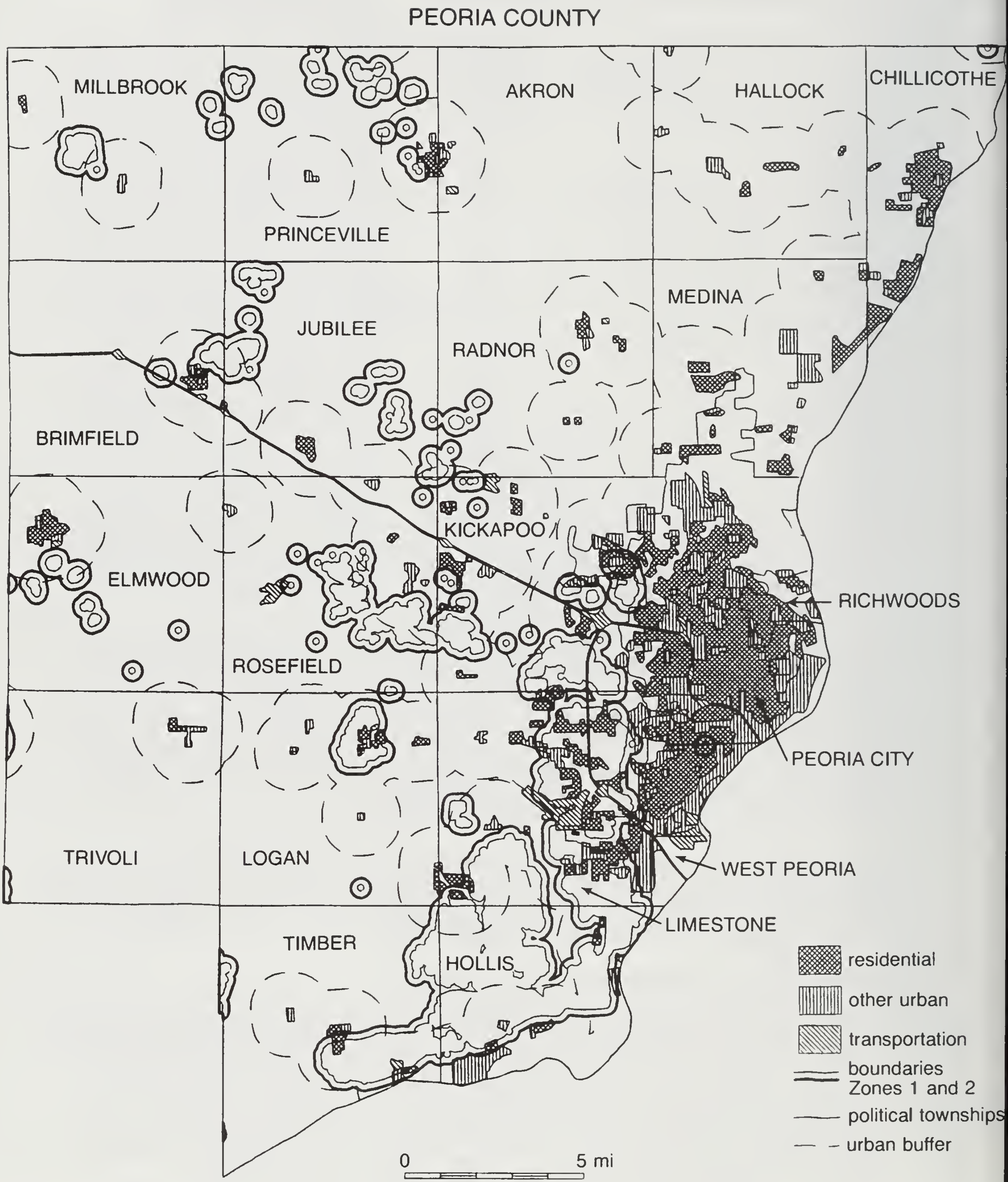

Figure 5 Undermined lands and built-up areas in Peoria County.

About half the townships in the 77 counties studied had a higher percentage of *urban buffer* land in Zone 1 than the percentage of *residential* or *other urban* land in Zone 1. In 49 of the 77 counties, more than 50 percent of the *nonurban* land in Zone 1 was within the urban buffer, and in 66 counties more than 20 percent of the *nonurban* land in Zone 1 was within the urban buffer. These statistics indicate that in many areas the number of structures exposed to potential subsidence will increase as urban areas expand.

CONCLUSIONS AND RECOMMENDATIONS

Approximately 178,000 acres of *residential* and other built-up areas in Illinois are in close proximity to underground mines and may be at risk from subsidence. In addition, 877,000 acres of undermined land adjacent to urban areas pose a potential threat to future urban expansion. Planners, developers, local government officials, and landowners should be aware of the general locations of these areas.

The tables in this report can be used to determine the amount of land in a county in close proximity to underground mines. County maps (scale, 1:100,000) showing the general location of mined areas are available from the ISGS. In major urban areas, however, detailed mapping of mines is necessary to delineate the position of mine boundaries accurately with respect to urban features. In a project now in progress at the Geological Survey, detailed mined-out area maps for urban areas are being constructed at a scale of 1:24,000. At this scale the approximate position of mine boundaries with respect to individual properties can be depicted. Information on the availability of these maps can be obtained from the Survey.

As more is learned about additional factors that contribute to subsidence, we can refine this assessment of exposure to potential mine subsidence. The GIS can be a valuable tool in identifying spatial correlations between subsidence events and other parameters.

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